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Tree Hazards

Recognition and Reduction in Recreation Sites

FOREST INSECT AND DISEASE MANAGEMENT
STATE AND PRIVATE FORESTRY
ROCKY MOUNTAIN REGION
FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

TREE HAZARDS:

RECOGNITION

AND

REDUCTION IN RECREATION SITES

by

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Technical Report R2-1

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ABSTRACT

Defective trees represent potential hazards to people and property in recreation areas. Most reported tree failures within recreation sites in the Rocky Mountain Region occur in lodgepole pine and aspen. Defective root systems account for the greatest percentage of failures. External indicators of possible defect are used to evaluate potential tree failures. Certain forest types, such as aspen, are highly susceptible to visitor damage; managers should restrict recreational development in such types. Documentation is an important part of hazard tree analysis.

ACKNOWLEDGMENT

Appreciation is expressed to Dr. Lee A. Paine, Forest Pathologist, Pacific Southwest Forest and Range Experiment Station, Berkeley, California, for tree failure report data. His data, obtained from forest management agencies, have been summarized into tables.

INTRODUCTION

Importance of Tree Hazard Recognition and Reduction

Portions of the Forest Service Manual (FSM 2303; 2330; 6703; 6730) outline specific objectives, policies and responsibilities in regard to (1) recreation area hazard tree evaluation, (2) documentation, and (3) corrective action. Basically, these regulations specify that safeguarding public health and safety and protection of natural forest resources at all Forest Service public-use areas are of prime importance.

The information in this article is written primarily for the practicing forester or technician who has responsibility for the maintenance and protection of recreation sites, especially campgrounds, picnic, and winter sports areas. Hopefully this information will serve to stimulate greater awareness of tree hazards and encourage corrective action that can reduce costly tree failure accidents. Secondarily, the probability of expensive legal action resulting from tree failures involving forest visitors should be lessened.

No attempt has been made to discuss the specific indicators of defect for every tree species in the Rocky Mountain Region. This information is best presented during field training sessions by trained personnel.

What is a Tree Hazard?

In this discussion a tree hazard refers to any potential tree failure due to a structural defect that may result in property damage or personal injury. It is difficult to state the probability of tree failure with certainty because of the complex interaction of tree and environment in rendering a tree susceptible to failure. Every tree will eventually fail; therefore, knowledge of each tree species, site characteristics and local weather conditions is essential in evaluating tree hazards. A defective tree is hazardous only when its failure could result in damage to something of value. In recreation areas, we are concerned with structures, forest visitors, and their vehicles, or other property.

What is the responsibility of land managers regarding tree hazards?

The Federal Tort Claim Act (1946) provides that the United States is liable in the same manner as a private party for the negligent acts or omissions of its employees. The modern trend is to make the owner of the land responsible to exercise reasonable care to prevent harm to the person who might come on his land. In determining liability, the first question to be decided in all cases is: Has the owner been negligent in the use or management of his property? The second question to be decided, assuming that a negligent act was committed is: What duty does a landowner in the use and management of his real property owe to persons who enter his lands?

By legal definition, there are three classes of visitors on a tract of land: the invitee, the licensee, and the trespasser. The invitee is of primary concern to public land managers because every person visiting "land held open to the public" belongs in this category. Of the tree visitor classes, the invitee commands the greatest legal responsibility. The land manager owes a duty of care to the invitee not to injure him by some unreasonably dangerous conduct. Also, the manager must act with reasonable care to discover any unreasonably dangerous conditions on the premises and either to put the premises in a reasonably safe condition for the use of the invitee, or to warn the invitee of the danger and risk involved.

Responsibility to ensure public safety is roughly proportionate to the degree of development in a given land area. Highly developed sites such as campgrounds, picnic, and ski areas incur a greater level of liability than undeveloped areas.

Due to the fact that all trees have some chance of failure, it is not feasible to eliminate all tree hazards in a forested recreation area. For a land manager to protect himself from liability, it is necessary to use "reasonable care" to protect visitors. In most cases, "reasonable care" implies that areas such as campgrounds have been evaluated for safety hazards by a qualified person. Therefore, the best protection against liability is a documented program of annual inspections of recreation areas. Hazards should be identified and a decision made as to appropriate action. A program of documented safety inspections on a regular basis is essential in reducing hazards.

Are tree hazards important in the Rocky Mountain Region?

About 1,300 tree failures within recreation sites were reported for this five state region (Colorado, Kansas, Nebraska, South Dakota, and Wyoming) during the last 12 years (Table 1). Considering that this figure only includes reported failures, the actual number of tree failures is probably much higher.

TABLE 1 Number of reported tree failures by species group and state in recreational areas of the Rocky Mountain Region (USFS - Region 2) for the period 1965 - 1977. [a]

State	All Softwoods	Lodgepole Pine [b]	All Hardwoods	Aspen [b]	State Totals
Colorado	962	818 (85.0)	95	95 (100.00)	1,057
Wyoming	153	131 (85.6)	37	37 (100.00)	190
South Dakota	5	0 (0.0)	0	0 (0.0)	5
Nebraska	0	0 (0.0)	5	1 (20.0)	5
Kansas	1	0 (0.0)	37	8 (21.6)	38
Regional Total	1,121	949 (84.7)	174	141 (81.0)	1,295
Percent	86.6	73.3	13.4	10.9	

a Data obtained from Dr. Lee A. Paine, Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, Berkeley, California

b Percentage of all softwoods or all hardwoods given in parentheses.

Although most of these tree failures resulted in little or no damage (Table 2), there is always the possibility that an accident will occur. An accident requires both a tree failure and a target. The target may be a recreational structure or vehicle (causing monetary loss), or a forest visitor (resulting in personal injury). With the increasing popularity of outdoor recreation, corresponding to greater numbers of visitor days in developed recreation sites, the probability of a failing tree striking a target also increases. In the outdoor-conscious Rocky Mountain area, tree hazards merit serious consideration by all land managers.

Tree hazards are also important from an economic point of view. Usually, the amount of money lost in tort claims far exceeds the cost of safety maintenance. A court decision in Wyoming awarded over $43,000 for the death of a man in a National Park Service campground. He was struck by a tree with obvious physical defects that failed without unusual weather conditions (Menefee, 1973). With damage awards increasing each year, the relative cost of tree hazard evaluations becomes minimal indeed.

RECOGNITION OF TREE HAZARDS

Common tree defects that may indicate hazard

Hazardous trees may be classified into distinct categories. Each category exhibits unique symptoms and each has a given probability for failure. These categories are by no means discrete; a tree may exhibit several types of defects, thus the hazard is increased. The following categories are listed roughly in order of importance.

Dead Trees - Snags are the most dangerous type of tree hazard. Once a tree dies, decay organisms begin weakening tree structure. This deterioration occurs most rapidly in the butt portion and root system where moisture conditions are most favorable for decay. Structural weakening advances with time making older snags a formidable hazard; however, weathered snags can add scenic beauty to a recreation site and also provide valuable wildlife habitat. A dead tree must prove to be a threat before it becomes a hazard (Fig. 1).

Leaning Trees - Leaners constitute a threat only when they have resulted from structural damage. Trees that have a natural lean usually are reinforced by compensatory growth.

TABLE 2 Number of reported tree failures resulting in accidents (property damage) by state and species groups in recreational areas of the Rocky Mountain Region (USFS - Region 2) for the period 1965 - 1977. [a]

State	Species Group	Accident Failures [b]	Non-accident Failures	Total Failures
Colorado	Softwoods	25	937	962
	Hardwoods	1	94	95
Wyoming	Softwoods	10	143	153
	Hardwoods	2	35	37
South Dakota	Softwoods	0	5	5
	Hardwoods	0	0	0
Nebraska	Softwoods	0	0	0
	Hardwoods	0	5	5
Kansas	Softwoods	0	1	1
	Hardwoods	0	37	37
Totals for Region	--	38 (2.9%)	1,257 (97.1%)	1,295

a Data obtained from Dr. Lee A. Paine, Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, Berkeley, California.

b Failures resulting in accidents (property damage). No reported failures resulted in injuries or fatalities.

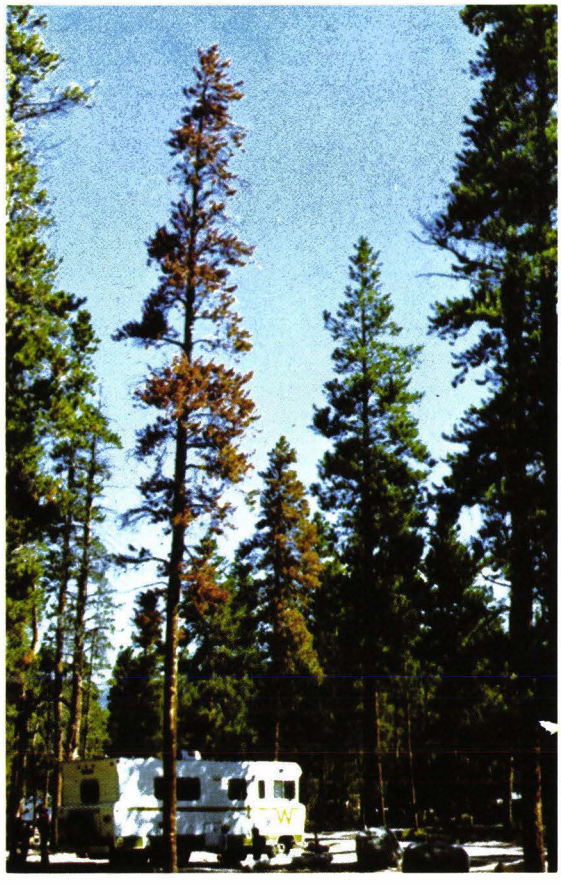


Figure 1

Dead trees are an obvious hazard in high-use areas and should be removed.

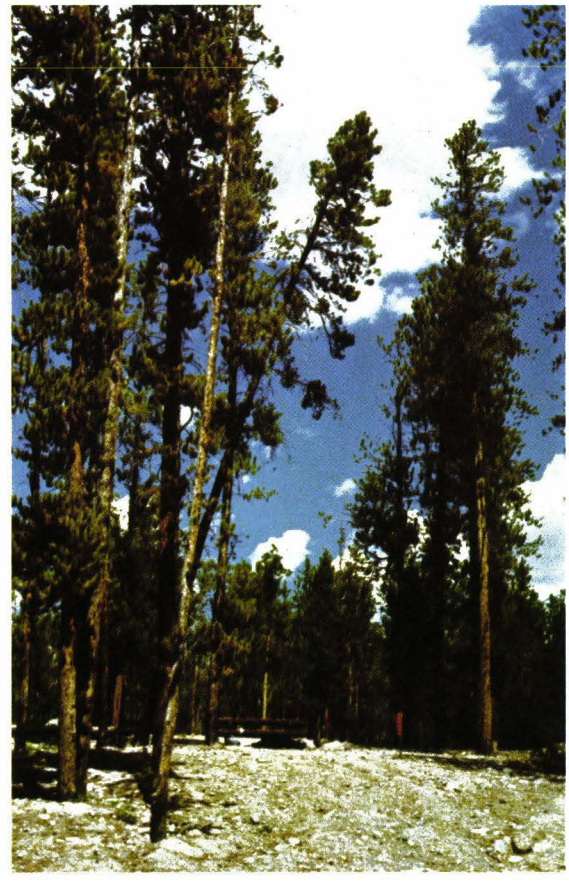


Figure 2

This leaning tree had a damaged root system and was threatening this picnic site.

Leaning trees are hazardous in direct proportion to their angle of declination. Often these trees become gradually weaker and a severe wind gust can lead to failure. In some cases, leaning trees may have aesthetic value but should be removed if they threaten visitor safety or recreational structures (Fig. 2).

Root Injuries - For lodgepole pine and aspen, about 85 and 50 percent of tree failures occurred in the root system, respectively (Table 3). The roots function as an anchor, providing the major resistance to windthrow. Any agent causing root damage increases the chance for failure. Wood-rotting fungi destroy wood fiber in the root system, greatly reducing strength and resistance to windthrow (Fig. 3). Visual symptoms indicating root injury may not be apparent; however, increment cores will usually reveal the presence of root rot. Sporophores (mushrooms or conks) around the base of the tree indicate advanced decay and therefore considerable hazard (Fig. 3).

Physical injury to roots can weaken tree structure and may also provide entry courts for rot fungi. Construction activities, vehicular and pedestrian traffic are often responsbile for direct injury to roots (Fig. 4). The root system may be injured indirectly through soil compaction or fluctuating water tables.

Trunk Injuries - Approximately 10 percent of lodgepole pine and 28 percent of aspen failures occurred in the trunk. The trunk must support the weight of the entire crown and any structural injury increases the chance for failure. Bole wounds provide entry for wood-rotting fungi that reduce the volume of sound wood and increase the probability of stem breakage. Forked trunks are structurally weaker than single stems. Burls, cankers, and scars do not affect stem strength unless complicated by rots (Fig. 5).

Crown Defects - Only a small percentage of lodgepole pine tree failures occurred in the crown region. Because of the smaller dimensions of crown components, damage potential is lower than for other parts of the tree. On very tall trees, however, branches falling from crown height can cause serious injuries. Spike-topped trees are not extremely dangerous unless they are rotten. Forked tops may be hazardous during periods of severe wind stress. Witches'-brooms, such as those caused by dwarf mistletoe or rust fungi, are not dangerous unless very large or dead.

TABLE 3 Location and frequency of tree failures reported for lodgepole pine and aspen in recreational areas of the Rocky Mountain Region (USFS - Region 2) for the period 1965 - 1977. [a]

Location of Failure	Lodgepole Pine Percent	Aspen Percent
Limb	1.0	9.9
Upper Bole	4.5	14.2
Lower Bole	5.7	13.5
Butt	3.7	12.1
Root	85.1	50.3
Total Reported Failures	949	141

[a] Data obtained from Dr. Lee A. Paine, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

Figure 3

Trees weakened by root rot fungi are susceptible to windthrow. Note conk of *Ganoderma applanatum* (= *Fomes applanatus*) at base of tree.

Figure 4

Injury to tree root and soil compaction can result from pedestrian traffic along trails.

Figure 5

Cankers infected with decay fungi indicate substantial structural defect.

Figure 7

Conks (*Phellinus tremulae* = *Fomes igniarius*) on aspen indicate extensive decay and should be checked with an increment borer.

Hazards of major forest communities

Each forest type possesses unique characteristics and each component tree species has its respective defects. The major forest communities in the Rocky Mountains are presented in terms of their specific hazards.

Pinyon-Juniper Type - There have been very few reported failures in this timber type. This may be due, in part, to the fact that few developed recreation sites are located in this forest type. In addition, hazards may be less because of the low physical stature of these trees. Juniper is relatively resistant to wood rots and has few other serious defects. Pinyon is affected by rots and other diseases and should be inspected on an individual basis. Because of the arid environment of these stands, trees are at a premium; they should be preserved when they are an important component of a recreation site.

Mixed-Conifer Type - The majority of reported failures occurred in this forest type. The pines and quaking aspen accounted for most of the total failures. Because of the inherent differences in these tree species, they are discussed separately.

Pines - Areas with predominant pine cover are commonly used for campgrounds and picnic areas. From the standpoint of potential tree hazards, the major difference between lodgepole pine and ponderosa pine is that lodgepole pine has very thin bark, which is easily damaged. Dwarf mistletoe is the major disease of pines in the Rocky Mountains and large witches'-brooms should be removed to eliminate hazard and improve tree vigor. Wood-rotting fungi are common in pines. Indicators of rot include basal fire scars, unusual swellings, swollen or punky knots and ideally, presence of sporophores. However, because of the dry climate in this region, most wood-rotting fungi rarely form easily-visible sporophores. Thus, on trees exhibiting suspicious symptoms, increment cores should be taken to confirm rot and determine the amount of sound wood. The thickness of sound wood in the outer shell determines structural strength in trees with rot defect. The minimum standards for safety based on bole diameter are presented in Figure 6. Rots must be considered together with other defects. For example, a leaning tree can tolerate less rot defect than an upright one. Root rots are, of course, the most critical and increment cores should be taken in the basal portion of suspect trees. Burls and cankers commonly occur on pines. These defects do not constitute a hazard unless they are so extensive as to weaken stem structure or are complicated by rot.

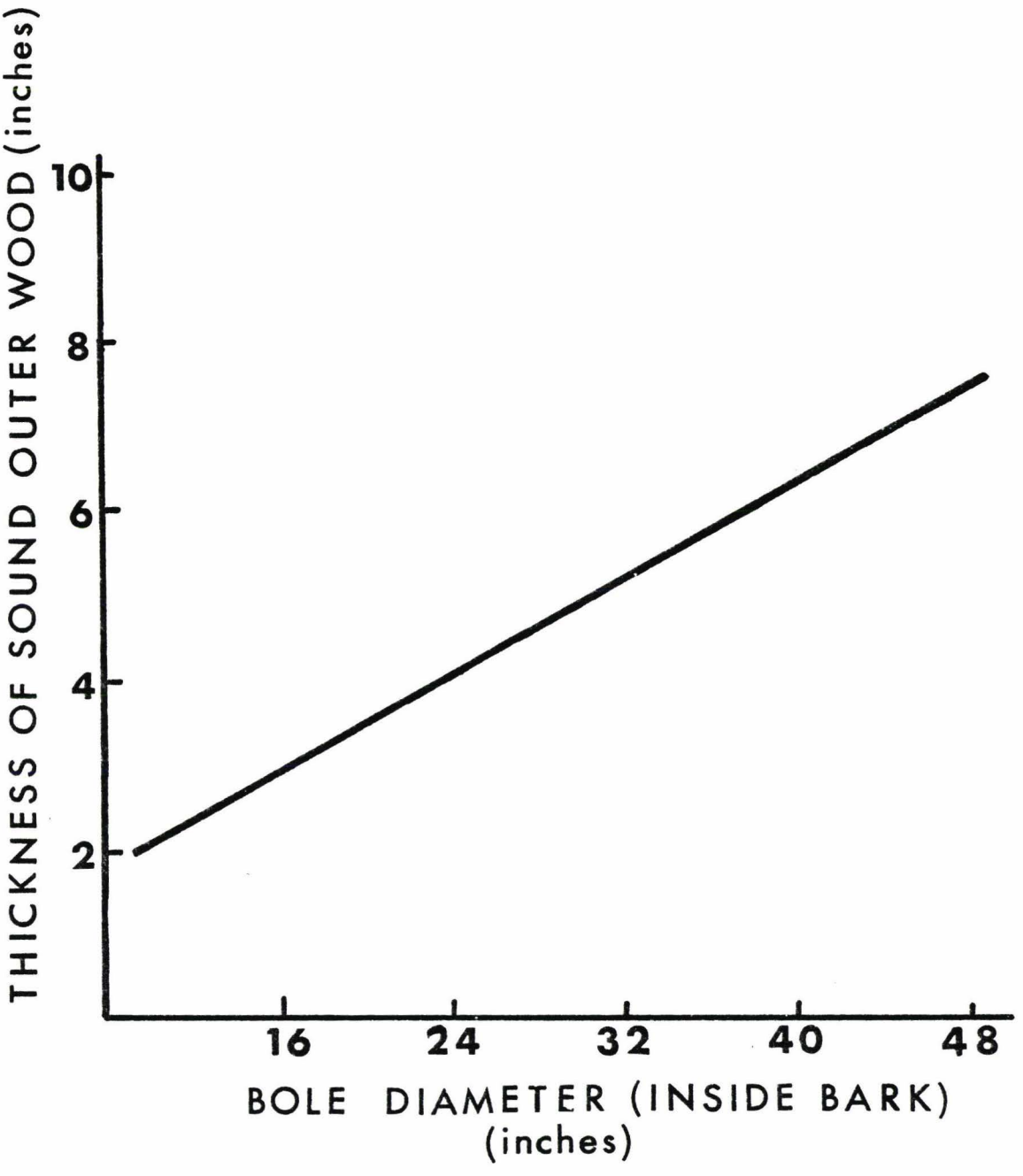


Figure 6 - Thickness of sound wood in outer shell required to maintain 66% of original strength in trees with heart rot (modified from Wagener, 1963). If the amount of sound wood exceeds that established by the line on the graph, the tree can be considered relatively safe from failure.

Aspen - Pure aspen stands usually contain many defective trees. Conks on aspen (Fig. 7) usually indicate decay that extends 5 - 6 feet above and below the conk. Aspen because of their fragile bark are especially susceptible to bole injuries. Trees in developed recreation sites are often injuried by visitors; such injuries often lead to infection by canker fungi (Fig. 8, 9). Cankers do not weaken trees structurally unless they are extensive or are compounded by rots. Increment cores may be necessary to define the amount of defect in this species; however, cores should be taken only when necessary, as they produce wounds which may provide infection sites for canker and decay fungi. Other tree species in the mixed conifer type should be evaluated for obvious defects and rots. Root rots should be the principal defects for investigation.

Spruce-Fir Type - This forest type has a significant number of reported tree failures annually. Rots commonly occur in overmature spruce and true fir. Subalpine fir is particularly susceptible to wood-rot fungi and the frequency and extent of rot increases markedly with age. Trunk wounds (Fig. 10), punky knots, frost cracks, and broken tops often indicate decay in spruce and fir; whereas, burls and cankers do not. Conks, when present, indicate advanced decay (Fig. 11 and 12). When defect is suspected, increment cores should be taken to confirm the presence of rot. Spruce and fir are not windfirm due to shallow root systems. Therefore, any damage to the roots will increase the probability of windthrow. Rust brooms, unless large, are not a serious hazard. Both spruce and true fir are relatively tolerant of bole damage.

Riparian Type - Bottomland forests are favorite recreation sites because of their location near water. Blue spruce and cottonwood are the most common species in this forest type. Blue spruce has basically the same type of defects as Engelmann spruce and should be evaluated similarly. The main defect of cottonwood is large dead or rotten branches (Fig. 13). Larger trees are often rotten and the amount of sound wood should be measured on increment cores. Slime flux (foul-smelling and unslightly bleeding from wounds) and wetwood should not be confused with wood-rotting fungi. These indicators are common in hardwoods and usually do not indicate decay. Because of the high water table and coarse soil structure, many river bottom trees are not windfirm.

TREE HAZARD EVALUATION

Basically tree hazard evaluation can be accomplished in three steps: identification, documentation and corrective action.

Figure 8

Cytospora canker of aspen. Infection is a result of tree injury by visitors in developed recreation sites.

Figure 9

Sooty bark canker (*Cenangium singulare*) of aspen. The fungus entered wounds caused by recreation area visitors.

Figure 10

Trunk wounds on Engelmann spruce and subalpine fir often indicate decay. This large catface indicates a column of decay in this tree.

Figure 11

Conks of *Phellinis pini* (*Fomes pini*) on Engelmann spruce indicates advanced decay.

Figure 12

Conk of the Indian Paint fungus (*Echinodontium tinctorium*) indicates advanced decay of this true fir tree.

Figure 13

Cottonwood that has failed because of decay.

Identification

Before initiating a tree inspection, the developed recreation area should be stratified into tree hazard risk zones (Fig. 14). Intensity of the inspection should vary directly with the risk level. All trees within falling distance of targets (structures, vehicles or recreationists) should be inspected. Tree height determines width of the hazard zone. The inspection should be concentrated in High Risk Zones (I) because concentrations of people and most structures are found in this area. This zone includes areas around designated camp or picnic sites and along major roads and trails. Medium Risk Zones (II) should be inspected as time allows since the priority is lower. Low Risk Zones (III) incur limited liability and regular inspections have low priority.

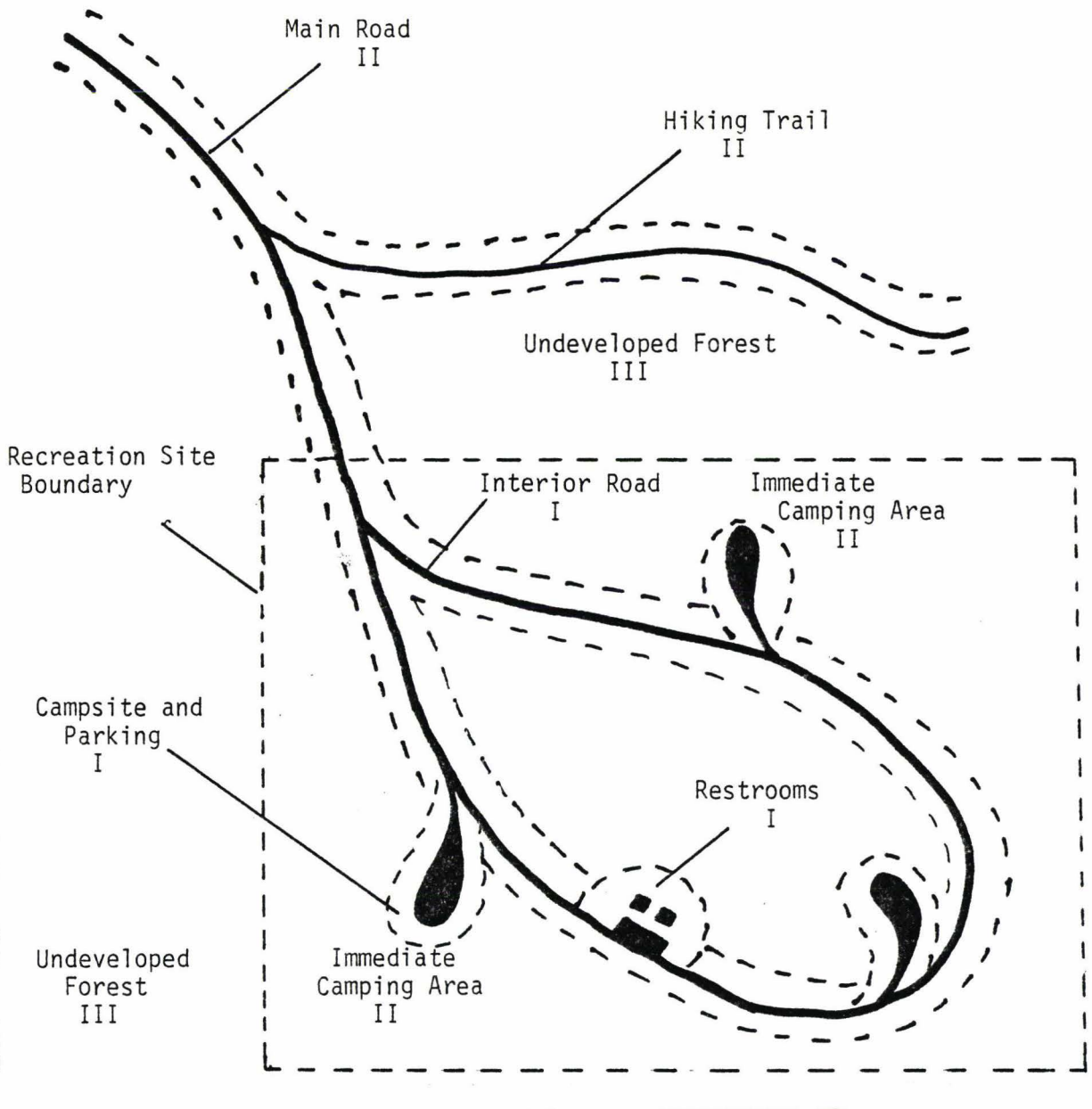
Trees must be evaluated individually. Due to differences in site, microclimate, developmental history and inherent genetic characteristics, trees vary in hazard potential. Defects must be considered in relation to external factors such as prevailing winds, location with respect to other trees, relative vigor and distance, and direction to a target.

The purpose of a hazard tree evaluation is NOT to remove every tree that exhibits defects; rather the goal should be to preserve the greatest number of trees in recreation areas consistent with safety requirements. Removal of too many trees in an area can destroy the aesthetic qualities for which the site was selected. Also, stand stability may be affected and the probability of windthrow increased.

Trees should be inspected in a systematic manner. Begin with the root system and work upwards toward the crown noting all defects. Examine all sides of the tree for rot indicators and take increment cores of suspect trees. Look carefully at the root system. After noting any structural defects, step back and consider aspects of the environment that may influence the hazard and note the proximity to any targets. Assign a risk rating to each tree (high, medium, or low) and decide on the type and priority of corrrective action. Trees of high risk would include those with substantial rot defect due to basal wounds and root rot as indicated by fruiting bodies. Constantly try to think of the benefits that a tree is providing as opposed to the hazard that it poses.

Documentation

It is extremely important to document hazardous trees. In order to reduce legal liability, a record is required. Documentation proves



TREE HAZARD RISK ZONES (zone width varies with tree height)

I High Risk - High use areas with concentrations of people, parked vehicles and permanent structures. Highest priority for regular inspections.

II Medium Risk - Intermittent use by people and moving vehicles. Low priority for inspections.

III Low Risk - No vehicles or structures and low visitor use. No inspection required.

Figure 14 - Recreation areas should be divided into hazard risk zones which determine the intensity of evaluation.

Trees adjacent to permanent structures, such as buildings and lifts, and along ski trails should be inspected annually for possible hazards prior to the use season (Figs. 15 and 16). Procedures for examination should be the same as those described for other recreation areas. Of special importance in ski areas are trees leaning over structures such as lifts. Structural damage has often occurred from this type of hazard (Fig. 16).

Trees with high risk ratings should probably be removed. Again, the goal of hazard analysis should be to locate and evaluate potential tree hazards and maintain the greatest number of trees possible consistent with safety requirements.

that the land manager is aware that hazards exist and that the area has been inspected for these hazards. High-use areas should be evaluated yearly. Inspections just prior to the recreation season are usually best. Summer and fall use areas should be inspected in the spring; whereas, winter use areas should be inspected in the fall. Permanent records should be maintained on each site to provide a case history. Documentation is best accomplished by use of a form that will insure that basic information has been gathered during each evaluation. A recommended form is included in the Appendix.

Corrective Action

This is the final step in the evaluation process. It is also the most expensive and time-consuming but greatly reduces the probability of serious damage, costly cleanup action and tort claims.

Action should be taken as soon as possible after the initial evaluation. Hazard reduction can often be accomplished by means other than tree removal. Pruning dangerous limbs or stimulating tree vigor can alleviate hazard. High-value scenic trees can be reinforced or the defective portion removed. In some instances the target (picnic table, rest rooms) can be moved to a safe distance. Marginally hazardous trees should be recorded on the form and observed over a period of time. If the risk of failure increases, corrective action should be undertaken.

TREE HAZARDS IN WINTER SPORTS AREAS

Ski areas provide unique problems with regards to hazardous tree management. Considerable alteration of stand composition occurs when ski areas are developed. Formerly protected trees become exposed when stands are opened as a result of construction of ski trails and lift lines. Such exposure often leads to greater tree failure due to windfall than occurred before the site was disturbed. The seasonal peak of visitor use in winter sports areas often corresponds to the time of year when many tree failures naturally occur; consequently, the potential for human injury as a result of tree failures may be greater in winter sports areas than in recreation sites with predominately summer use.

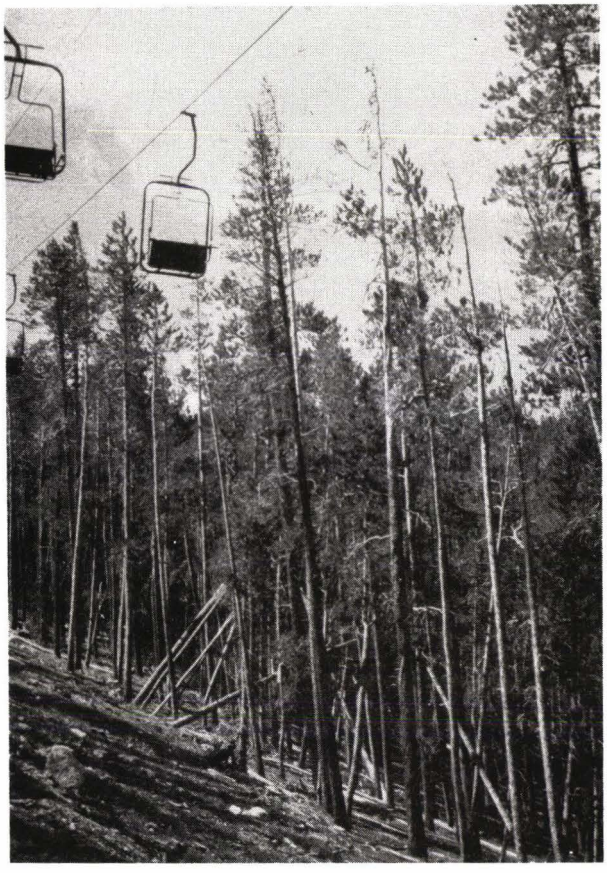


Figure 15

Defective trees adjacent to permanent structures, such as ski lifts, should be removed.

Figure 16

Engelmann spruce tree that failed and caused damage to this ski lift at Vail, Colorado.

APPENDIX

USDA — FOREST SERVICE
TREE HAZARD EVALUATION FORM

FOREST_____ RECREATION SITE_____

RETAIN THIS FORM IN DISTRICT FILES FOR 3 YEARS AND THEN DISPOSE

SUBMITTED BY_____

DISTRICT_____ DATE_____

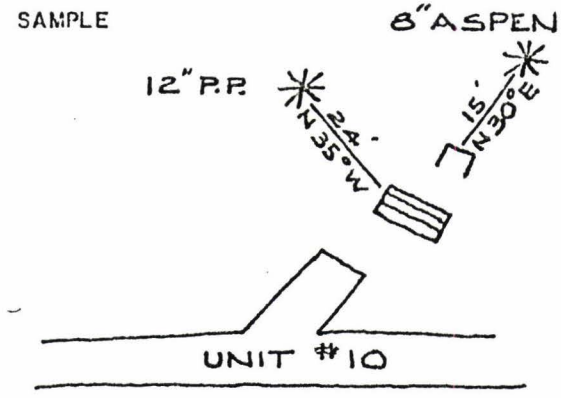
CAMPSITE OR PICNIC UNIT NO.	MAP NO. TREE LOCATION — COMPLETE MAP ON BACK OF FORM	TREE NO.	SPECIES	D.B.H.	TYPE OF DEFECT											POTENTIAL TARGET			ACTION TO BE TAKEN				ACTION PRIORITY				DATE ACTION WAS TAKEN	ADDITIONAL COMMENTS
					DEAD TREE	LEANING	UPROOTED	ROOT ROT	BUTT ROT	BASAL CAVITY	WEAK CROTCH	LIMB DEFECT	BROOMS	MECHANICAL INJURY	OTHER (EXPLAIN)	PERMANENT STRUCTURE	PARKED VEHICLE	PEOPLE	FELL	BRANCH REMOVAL	CROWN REDUCTION	TOP	HIGH	MEDIUM	LOW	OBSERVE		

REFERENCE: Tree Hazards: Recognition and Reduction In Recreation Sites. Rocky Mtn. Region. Tech. Rept. R2-1

R2-2300-11(1/78)

HAZARD TREE LOCATION

SAMPLE



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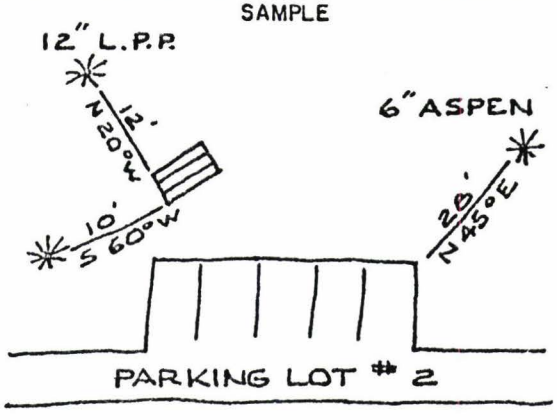

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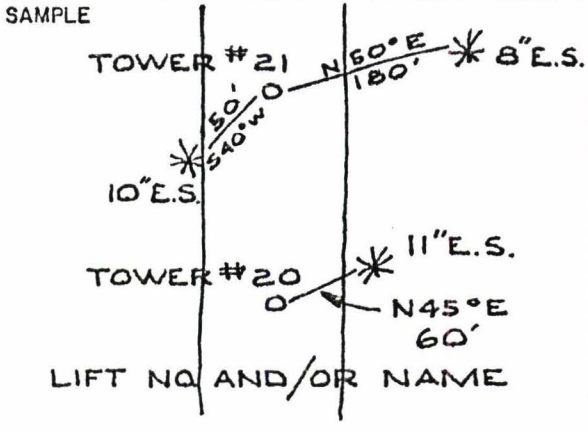

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